

# OPERATING INSTRUCTIONS

## Mini OEM Module CAP100

### Contents

1	PRODUCT DESCRIPTION AND INTENDED USE.....	3
2	STRUCTURE OF THE DEVICE.....	3
3	MAIN FEATURES .....	4
3.1	STANDARD PERFORMANCE FEATURES.....	4
3.2	OPTIONAL FUNCTIONS.....	4
4	SAFETY INSTRUCTIONS.....	5
5	INITIAL OPERATION.....	7
5.1	TUBE LAYOUT FOR CAP-100.....	7
5.2	FEEDING MEASUREMENT GASES.....	9
5.3	WATER FILTER.....	9
5.4	INTERNAL NAFION GAS DRYER.....	9
5.5	EXTERNAL NAFION GAS DRYER.....	9
5.6	CO <sub>2</sub> ABSORBER CARTRIDGE.....	9
6	PIN AND CONNECTOR ALLOCATION.....	13
6.1	SUPPLY VOLTAGE.....	14
6.2	SERIAL INTERFACE.....	14
6.3	SERIAL INTERFACE WITH OPTO-COUPLER (OPTIONAL).....	14
6.4	ALTERNATIVE PUMP.....	14
6.5	ALTERNATIVE 3/2-WAY VALVE (OPTIONAL).....	15
6.6	RESET.....	15
6.7	ANALOG OUTPUT (OPTIONAL).....	16
7	OPERATION AND PROGRAM CYCLE.....	17
7.1	GENERAL PROGRAM CYCLE.....	17
7.2	ZERO POINT CALIBRATION.....	17
7.3	N <sub>2</sub> O COMPENSATION.....	18
7.4	ANALOG OUTPUT OPTION.....	18
7.5	FLIGHT USE OPTION.....	18
7.6	3/2-WAY VALVE OPTION.....	18
8	SERIAL PROTOCOL.....	19
8.1	GENERAL.....	19
8.2	TRANSMISSION PROTOCOL.....	19
8.2.1	<i>Identifications</i> .....	19
8.2.2	<i>CO<sub>2</sub> waveform (capnogram)</i> .....	19
8.2.3	<i>etCO<sub>2</sub></i> .....	20
8.2.4	<i>Respiration rate</i> .....	20
8.2.5	<i>Information</i> .....	20
8.2.6	<i>Unrequested status messages</i> .....	22
8.3	RECEIVE PROTOCOL.....	22

8.3.1	<i>Identifications</i>	22
8.3.2	<i>Information and status queries</i>	22
8.3.3	<i>Settings</i>	24
9	<b>CAP100 DEMO KIT</b>	<b>26</b>
9.1	CONNECTION OF SAMPLE TUBES	26
9.2	CONNECTION TO THE PC	26
9.2.1	<i>Supply and RS232 connection only with CAP100 module without motherboard</i>	26
9.2.2	<i>Supply and RS232 connection with motherboard</i>	27
9.3	STARTING THE DEMO PROGRAM	28
9.4	HELP	29
10	<b>MAINTENANCE</b>	<b>31</b>
10.1	ANNUAL MAINTENANCE	31
10.2	CALIBRATION CHECK	31
11	<b>TECHNICAL SPECIFICATIONS</b>	<b>32</b>
12	<b>CE MARKING</b>	<b>34</b>
13	<b>WARRANTY</b>	<b>34</b>

## 1 Product description and intended use

CAP100 is a module for measuring and monitoring the end tidal CO<sub>2</sub> concentration or the CO<sub>2</sub> partial pressure of the respiratory gas and the respiration rate. For fast and quantitative recordings these parameters are used by infrared spectroscopy. CAP100 is designed as a sidestream capnograph. From the respiratory flow of the patient a pump sucks in respiratory gas at an adjustable gas flow. The respiratory gas is fed to a measurement cell via a drying filter where the dry gas is analyzed for its CO<sub>2</sub> concentration.

CAP100 is a module which records the capnogram in the sidestream mode and calculates the end tidal CO<sub>2</sub> values (etCO<sub>2</sub>) as well as the respiration rate. All calculation functions, reference measurements as well as control functions of the pneumatic elements (pump, valve) are carried out by a CPU integrated in the module. The module has a serial port to transfer all data to a host computer. Through this port the user can also download new software updates. For demonstration purposes, a PC program is available for visually displaying all of the data.

## 2 Structure of the device

### Sensor unit

- CO<sub>2</sub> sensor consisting of cell with emitter and receiver with analog circuitry
- Valve for internal zero point calibration
- EMI screening
- Pump

### Digital processing unit and power supply

- EEPROM to save the calibration data and setup parameters
- Flash for downloading software
- Serial port
- Pressure sensor with analog circuitry for compensating barometric influences
- Stabilized voltage supplies
- Control systems for the pump, valve and the lamp

## 3 Main features

### 3.1 Standard performance features

- Bi-directional serial port
- Transfer of capnogram every 40 ms
- Transfer of etCO<sub>2</sub> and respiration rate every second
- Automatic temperature and pressure compensation
- Adjustable flow
- Adjustable mean calculation
- Nitrous oxide gas compensation
- Watchdog timer
- Boot flash for software updates

### 3.2 Optional functions

- Flight use (increased barometer measurements)
- 5 KV isolation through opto-coupler
- Analog output
- Free power driver to activate another valve (100 mA)

Connection to the host computer:

The serial port from and to the CAP100 device has TTL level. To send and receive data through an RS 232 port (e.g. PC) the data has to be converted through an RS 232 driver (e.g. MAX 232). In the demo kit this TTL-RS232 adapter is integrated on a motherboard (see chapter 9).

## 4 Safety instructions

Please read the following points for your own safety and in accordance with the requirements of the medical products directives.

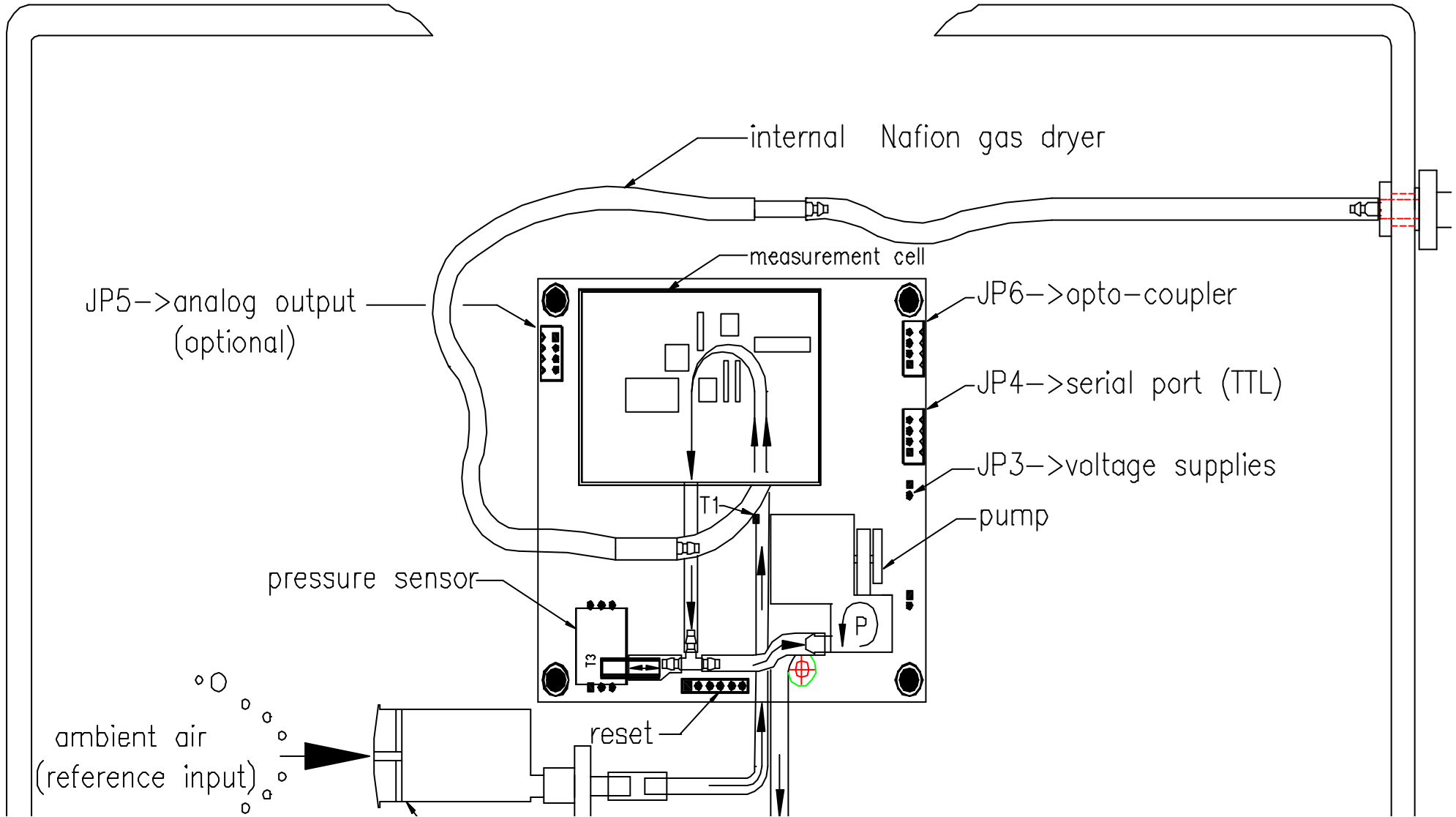
- Please read the instructions carefully. They are part of CAP100.
- CAP100 is only intended for use for the purpose specified.
- CAP100 may only be used by qualified personnel. When working with CAP100 the knowledge of the following aspects is assumed:
  - how to use a computer
  - electronic skills
- Please always use the water filter as a water trap. It prevents moisture and dirt from penetrating the measurement cell. Make sure the filter is tightly fitted as measurement deviations can arise if it is fitted loosely.
- Moisture penetrating CAP100 whilst it is in operation or storage can cause a failure of the module.
- The gas outlet may not be covered or closed.
- Do not position CAP100 directly next to the patient's expiratory flow. There is a risk of an incorrect CO<sub>2</sub> measurement in the reference channel.
- Incorrect measured values can be caused due to the proximity of:
  - interference from an electrical surgical unit
  - X rays
  - nuclear magnetic resonance tomographs
- CAP100 does not have any alarm functions.
- Please observe the service intervals. Service may only be carried out by authorized or trained personnel.
- EnviteC accepts no liability, if the device is incorrectly serviced by the owner or operator, or if it is handled in a way which is not in keeping with its intended use.
- CAP100 may not be submerged in fluid or cleaned with fluid agents.
- CAP100 may not be directly connected to a gas bottle, as too high a pressure can destroy the device. When connecting calibrating gases, insure that the gas flow can always escape through a Y piece.
- CAP100 may only be operated and stored under the ambient conditions stated in the technical specifications.



## **5 Initial operation**

### **5.1 Tube layout for CAP-100**

instrument



## 5.2 Feeding measurement gases

- Connect the tube to the inlet of your system. Please take care that CAP100 is always operated with a teflon filter and dryinf filter (internal Nafion) in front of the gas inlet. It prevents water from penetrating the measurement cell. Dirt and water can destroy the measurement cell. The system is then unable to take measurements.
- The CAP100 module has an input for reference air. CAP100 carries out automatic zero point calibrations during operation, by switching over a valve to the reference gas ambient air. At this input, it must be insured that there is no CO<sub>2</sub> in the ambient air. Make sure the ambient air is free of CO<sub>2</sub>. We recommend a CO<sub>2</sub> absorber cartridge being connected to this input.
- The analyzed gas is removed from the system through the pump. If the module is integrated in a housing, the outlet of the pump has to be led out of the housing.

## 5.3 Water filter

The water filter has a 0.5µm thin dehydrating diaphragm and prevents secretions or drops of water from entering the measurement device. Simultaneously, it reduces the risk of a contamination with bacteria or viruses. When the capacity of the water filter is exhausted, it lets air pass through and CAP100 issues an occlusion message. Change the water filter and confirm the occlusion message is no longer present. The water filter can be used for 2-3 hours without an external Nafion gas dryer.

## 5.4 Internal Nafion gas dryer

The Nafion gas dryer withdraws humidity or water vapor from the respiratory gas. The humidity is continuously exchanged with the ambient air. To measure the CO<sub>2</sub> content, an internal Nafion gas dryer (within your device) has to be connected between the water filter and in front of the measurement cell, as water vapor in the measurement cell can affect the accuracy. The Nafion gas dryer is maintenance-free and regenerates itself, as long as the surface is not contaminated by particles or condensate.

## 5.5 External Nafion gas dryer

You can increase the measurement time with CAP-100 to approx. 20 hours, by connecting an extra external Nafion gas dryer in front of the water filter. This gas dryer fulfills the same function as a water trap, which is used in other devices.

Never carry out a continuous measurement without the external Nafion gas dryer, as the humidity absorption capacity of the water filter is too low. Disinfect the external Nafion gas dryer after each patient and dry it completely afterwards, by operating CAP-100 for about 30 minutes in the normal measurement mode without patient tube and only with a water filter.

## 5.6 CO<sub>2</sub> absorber cartridge

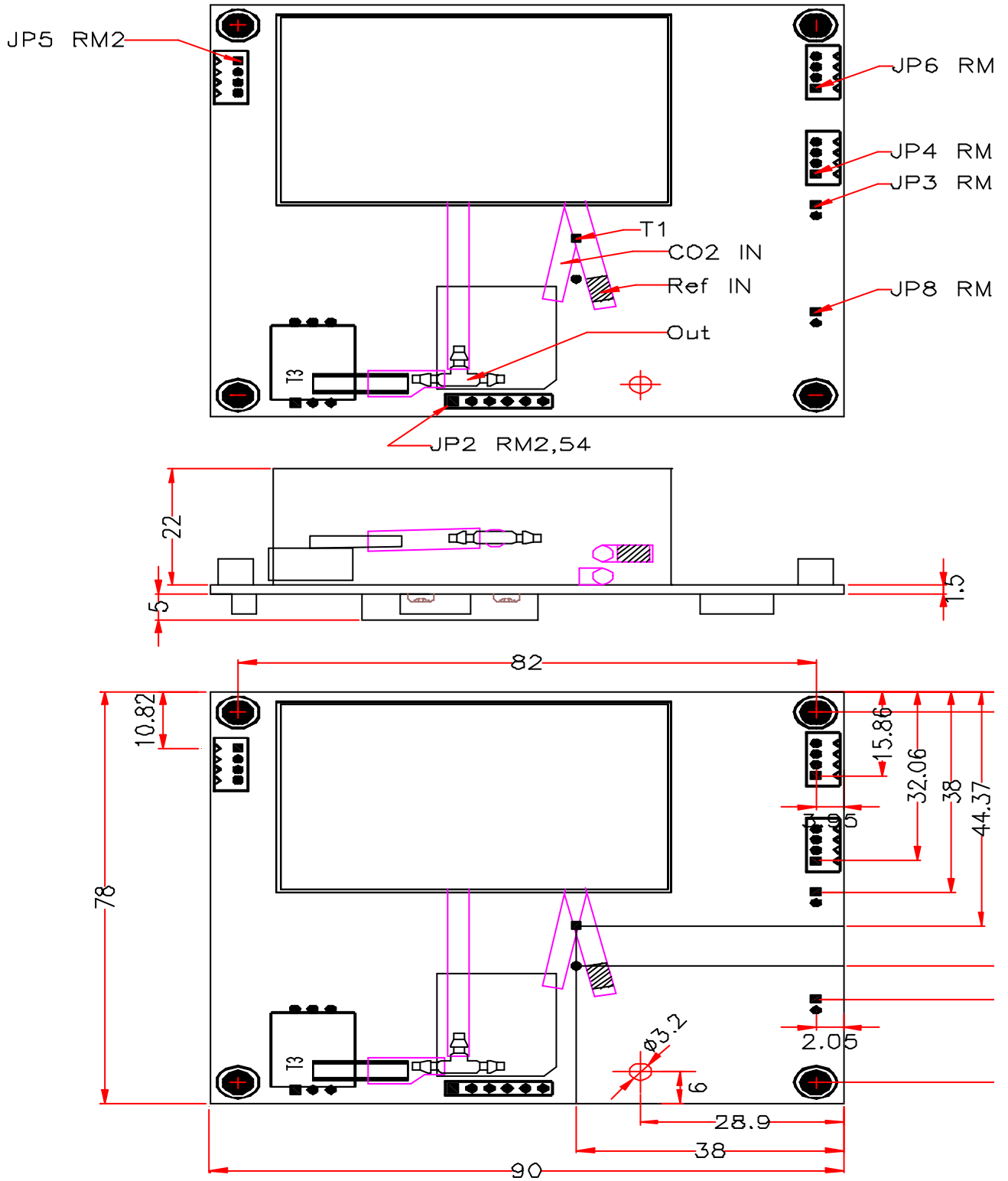
CAP-100 carries out zero point calibrations, by the CO<sub>2</sub> measurement values being related to a reference value (ambient air). This reference value has to be free of CO<sub>2</sub>; as otherwise you receive

incorrect measurements. During this calibration CAP-100 switches over the 3/2-way valve to this reference input. The CO<sub>2</sub> absorber cartridge is used to filter CO<sub>2</sub> from the ambient air. Insure the air is free of CO<sub>2</sub>, if you are not using a CO<sub>2</sub> absorber cartridge.



Illustration of the CO<sub>2</sub> absorber cartridge

## 6 Pin and connector allocation



This figure shows the layout of the inputs and outputs for the initial electrical operation. All pins and terminals have to be connected as shown in the following chapters.

### 6.1 Supply voltage

Plug: Jp 3                      2 pole, grid dimension 2.54 mm

Pin no.	Function
1	V+    +7V => +15 V DC (min. 300 mA)
2	GND   0 V

### 6.2 Serial interface

Plug: Jp 4                      4 pole, grid dimension, 2 mm

Pin no.	Function
1	RXD   TTL of CAP-100
2	TXD   TTL of CAP-100
3	GND
4	N.C.

### 6.3 Serial interface with opto-coupler (optional)

The serial interface is electrically isolated up to 5 KV through an opto-coupler (TTL).

Plug: Jp 6                      4 pole, grid dimension 2 mm

Pin no.	Function
1	Collector open                      (TxD + )
2	LED +, currentless                      (RxD +)
3	Emitter open                      (TxD - )
4	LED -, currentless                      (RxD -)

### 6.4 Alternative pump

With CAP100, you have the option of connecting another pump.

Plug: T1                      2 pole, grid dimension 7. 62 mm

Pin no.	Function
1	Pump +, VCC +5V, max. 100 mA

2	Pump -, GND 0 V
---	-----------------

**Attention:** The pump is controlled through pulse-width modulation. Check if your pump permits this type of control.

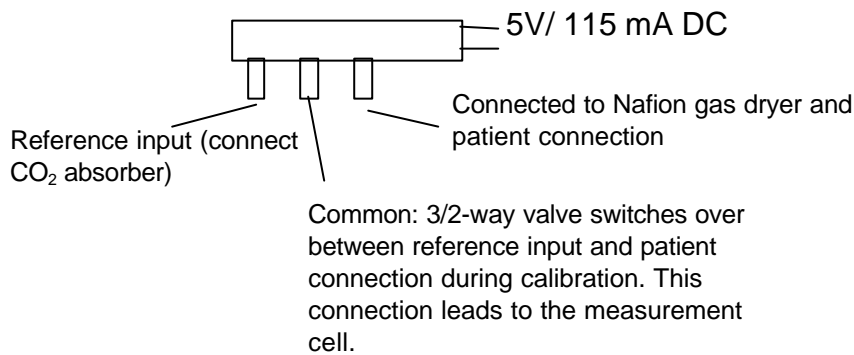
### 6.5 Alternative 3/2-way valve (optional)

Attention: CAP100 activates the valve automatically.

Plug: Jp 8                      2 pole, grid dimension 2.54 mm

Pin no.	Function
1	VCC +5V, max. 115 mA
2	GND 0 V

Connection:



### 6.6 Reset

The hardware reset is High active. The reset is carried out by connecting PIN 6 to PIN 3 by means of a key or switch.

Plug: Jp 2                      6 pole, grid dimension 2.54 mm

Pin no.	Function
1	Occupied by CPU
2	Occupied by CPU
3	Reset (High active)
4	Occupied by CPU
5	Occupied by CPU
6	VCC, + 5V (is applied)

### 6.7 Analog output (optional)

CAP100 features two analog outputs. You also have the option to switch the analog output from 0-1V to 0-100mV by software.

The output resistance is 1 kohm.

Plug: Jp 5                      4 pole, grid dimension 2 mm

Pin no.	Function
1	Capnogram: 0-75 mmHg = 0-1 V; 8 bit (0-100mV)
2	etCO <sub>2</sub> :                      3-75 mmHg = 0-1 V; 8 bit (3-100mV)
3	GND
4	N.C.

## 7 Operation and program cycle

### 7.1 General program cycle

After starting up the system (ports, variables, serial interface: 9600-1-8-1-N, I<sup>2</sup>C bus), pump initialization, nitrous oxide gas setting, default parameters, as well as after running through the various test routines (FLASH, RAM, EEPROM, analog values) the device carries out an initial calibration. After this, the main program works in a continuous loop with a cycle time of 40 ms, which is generated by a timer interrupt.

In the measurement mode, the measured values (pressure, temperature, molar concentration, supply voltage) are measured by the timer interrupt (every 5 ms) to guarantee equidistant scanning times.

The system calculates the extinction according to the law of Lambert Beer. After this, on the basis of the general gas equation, the relative concentration in %vol. is determined. From the course of the capnogram curve the respiration rate and the CO<sub>2</sub> partial pressure of the etCO<sub>2</sub> is determined.

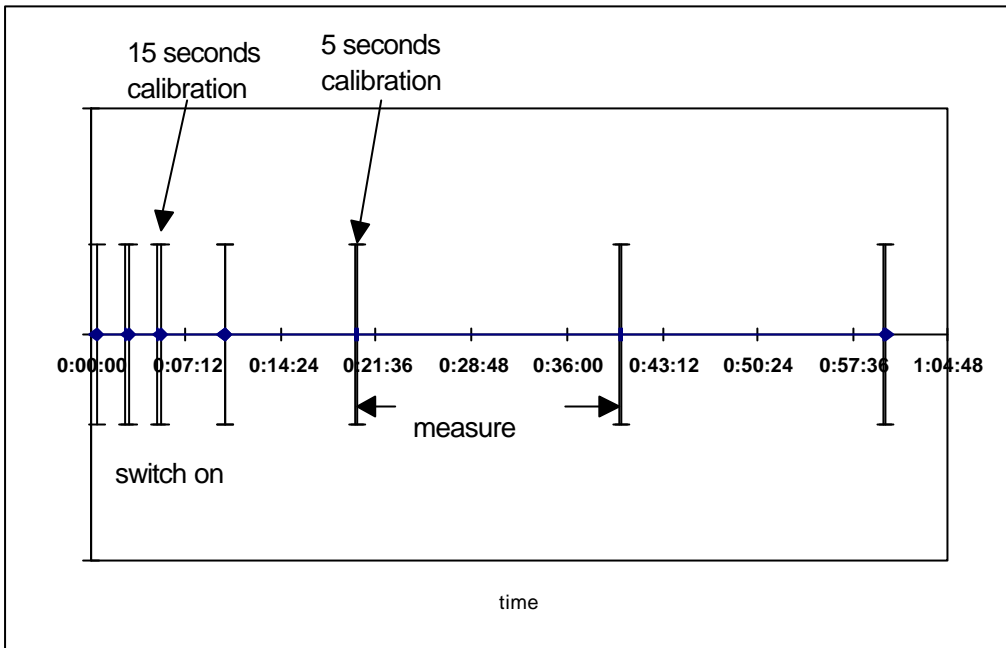
The patient's expiratory gas is dried before entering the measurement cell of CAP100. So that the measured values reproduce the actual conditions in the humid expiratory air, CAP100 includes the water vapor partial pressure of air saturated with humidity (water vapor correction). Parallel to the measurement procedure, CAP100 carries out tests of the sensor and electronic system. If an error arises, a corresponding identification is issued.

After each program cycle (40 ms) the capnogram curve, after each second the respiration rate and the etCO<sub>2</sub> value are transmitted. If an occlusion occurs (blockage of the tube or filter), the pump automatically switches off. The system sends an occlusion report, which has to be confirmed. During this time no measurement values are transmitted.

### 7.2 Zero point calibration

CAP100 carries out automatic zero point calibrations during operation. Temperature changes and changes in air pressure are measured and automatically compensated for. The calibrations are carried out at intervals of 20 minutes and last approx. 3-4 seconds. During this time CAP100 transmits an identification for calibration. No measured values are transferred. These fixed times are however shortened in the event of very large changes of the ambient conditions (e.g. high temperature differences). CAP100 recognizes these changes independently.

In order to achieve a stable system state after switching on the system, CAP100 carries out the calibrations at the following intervals:



*Temporal course of the zero point calibrations for CAP100 after switching on*

The temporal course of the calibration depends on temperature influences and fixed time intervals.

### 7.3 N<sub>2</sub>O compensation

The measurement accuracy of CAP100 is influenced by the presence of N<sub>2</sub>O. It is possible to compensate the frequently used nitrous oxide gas concentrations of 30% and 70%.

**Attention:** The nitrous oxide gas influence at 30% and 70% is not measured but arithmetically compensated!

### 7.4 Analog output option

CAP100 can be equipped with two analog outputs: The capnogram curve on channel A and the etCO<sub>2</sub> one on channel B. The factory setting of CAP100 is the output voltage of 0-1V. This corresponds with a partial pressure of 0-75 mmHg. You can switch over this output voltage to 0-100 mV. During the calibration, as well as in the event of occlusion, the channels are switched between 0 V (3 s) and 1 V (3 s). Additionally, during the measurement you can trigger a scaling signal with an identification. For 3 seconds 0 V is transferred, and for 3 seconds 1 V (or 100 mV).

### 7.5 Flight use option

The flight use setting is carried out by software. In this mode, CAP100 carries out an additional barometer measurement every minute so that fast differences in height can be compensated. In the event of fast differences in height inaccuracies can arise without additional compensation.

**Attention:** In this mode no occlusion is triggered.

### 7.6 3/2-way valve option

In this version, the CAP100 software automatically changes over the valve in the event of calibrations.

## 8 Serial protocol

### 8.1 General

The serial transmission protocol (TxD) is transmitted with TTL level. The protocol is set to 9600 baud, 8 data bits, 1 stop bit, no parity. The capnogram is transferred at 25 Hz (40 ms) in mmHg. The respiration rate and the etCO<sub>2</sub> value are transferred at fixed intervals of one second. The serial reception protocol is also based on TTL level.

### 8.2 Transmission protocol

#### 8.2.1 Identifications

The transmission protocol of CAP100 is structured with identifications. Thus for example, before each CO<sub>2</sub> value and respiration rate value, one byte is sent as identification. As a result the corresponding value can be filtered out of the data flow. The corresponding identification is subsequently followed by corresponding information or measured values.

Identification	Byte
Capno identification	0xE1
Capnogram	0xEC
etCO <sub>2</sub>	0xF1
Respiration rate	0xF0
Information	0xFB

**Attention:** These identifications are active as long as no further identification is sent.

#### 8.2.2 CO<sub>2</sub> waveform (capnogram)

In mmHG

Identification	Sequential byte	Meaning
0xEC	0x00 – 0x4B	0-75 mmHg capnogram

In % vol.

Identification	Sequential byte	Meaning
0xEC	0x00 - 0x63	0-9.9% vol. capnogram

**Attention:** When transferring the capnogram and the etCO<sub>2</sub> in % vol., the measured values are transferred in bytes. Thus for example 5.1 %vol. is multiplied by factor 10 and transferred. For evaluation purposes, the value transferred has to be divided by 10.

If there is no other Identification after the capnogram identification and capnogram value, the capnogram values are always transferred. The capnogram is sent at a frequency of 25 Hz (40 ms).

### 8.2.3 etCO<sub>2</sub>

In mmHg

Identification	Sequential byte	Meaning
0xF1	0x03 - 0x4B	3-75 mmHg etCO <sub>2</sub>

In % vol.

Identification	Sequential byte	Meaning
0xF1	0x03 - 0x63	0-9.9% vol. etCO <sub>2</sub>

**Attention:** When transferring the capnogram and the etCO<sub>2</sub> in % vol., the measured values are transferred in bytes. Thus for example 5.1 %vol. is multiplied by factor 10 and transferred. For evaluation purposes, the value transferred has to be divided by 10.

If there is no other Identification after the etCO<sub>2</sub> identification, the etCO<sub>2</sub> values are always transferred. The etCO<sub>2</sub> value is sent at a frequency of 1 Hz (1 sec).

### 8.2.4 Respiration rate

Identification	Sequential bytes	Meaning
0xF0	0x02 - 0x3C	2-120/min respiration rate

If there is no other identification after the respiration rate identification, the respiration rate values are always transferred. The respiration rate is sent at a frequency of 1 Hz.

Example of the transferred data:

Capnogram								etCO <sub>2</sub>		AF		mmHg	
0xEC	0x00	0x02	0x06	0x0C	0x15	0x1F	0x25	0xF1	0x25	0xF0	0x0E	0xE1	0x78

Meaning:

Capnogram in mmHg								etCO <sub>2</sub> /mmHg		AF in 1/min		mmHg	
0xEC	0	2	6	12	21	31	37	0xF1	37	0xF0	14	0xE1	0x78

### 8.2.5 Information

The information identification 0xFB is followed by the information code as well as various sequential bytes.

Identification	Information code/byte	Meaning and sequential bytes
0xFB	0x00	<b>Status OK</b> , after eliminating errors
0xFB	'S' = 0x53	<b>Code number</b> , followed by 20 bytes, which contain the code number
0xFB	'E' = 0x45	<b>Error code</b> , followed by 3 bytes, which contain the error message e.g.: 0x02
0xFB	'V' = 0x76	<b>Software version</b> , followed by 14 bytes, which contain the version

The following error messages can be transferred:

**1. System errors (no measuring possible any more)**

Identification	Code for system error	Error byte	CR	LF	Meaning
0xFB	0x45	0x02	0x0D	0x0A	RAM cell error
0xFB	0x45	0x03	0x0D	0x0A	RAM address error
0xFB	0x45	0x04	0x0D	0x0A	Sensor error
0xFB	0x45	0x05	0x0D	0x0A	Pump error
0xFB	0x45	0x06	0x0D	0x0A	Pressure sensor error
0xFB	0x45	0x07	0x0D	0x0A	Flash memory faulty
0xFB	0x45	0x14	0x0D	0x0A	RS232 error
0xFB	0x45	0x1E	0x0D	0x0A	Supply voltage too low
0xFB	0x45	0x1F	0x0D	0x0A	D/A transducer error (only for analog output option)

**2. Limited measurement possible, device has to be serviced**

Identification	Code for system error	Error byte	CR	LF	Meaning
0xFB	0x45	0x01	0x0D	0x0A	Calibration error (e.g. inspiratory CO <sub>2</sub> )

Example for sent information with error code (RAM cell error):

Info	Code	Error	CR	LF	Meaning
------	------	-------	----	----	---------

0xFB	0x45	0x02	0x0D	0x0A	RAM cell error
------	------	------	------	------	----------------

In the event of system errors, CAP100 switches to a status, which prevents measurements from being taken. Errors arising from inaccurate calibration enable measurements to be taken, these may however be inaccurate.

### 8.2.6 Unrequested status messages

During its normal measurement operation, CAP100 sends status messages such as an identification for the calibration. To this end the **capno identification 0xE1** is sent.

Identification	Status message	Meaning
0xE1	'P' = 0x50	Calibration is carried out
0xE1	'<' = 0x3C	No CO <sub>2</sub> in the system (after 30 s)
0xE1	'o' = 0x6F	Occlusion, tube system blocked
0xE1	'x' = 0x78	Measured value transfer in mmHg
0xE1	'y' = 0x79	Measured value transfer in % vol.

These values are transferred every second if they arise.

## 8.3 Receive protocol

### 8.3.1 Identifications

The receive protocol of CAP100 is structured like the transmission protocol with identifications. Thus for example before each command for setting a parameter one byte each has to be sent as an identification.

Identification	Byte
Capno identification	0xE1
Information	0xFB

### 8.3.2 Information and status queries

With CAP100 you can call up the parameters set (e.g. means, software version etc). To do this, you have to send the corresponding commands to CAP100. CAP100 replies with the corresponding status messages. CAP100 only sends these status messages after being requested to do so. To call up general information from CAP100, send the following commands:

Identification	Information query code/byte	Meaning
----------------	-----------------------------	---------

0xFB	'S' = 0x53	CAP100 is requested to send the code number (also see chapter Transmission protocol/Information)
0xFB	'v' = 0x76	CAP100 is requested to send the firmware version (also see chapter Transmission protocol/ Information).

To call up set parameters from CAP100, send the following commands:

Identificat ion	Status query code/byte	Meaning
0xE1	'0' = 0x30	CAP100 is requested to send the mean set of the etCO <sub>2</sub> value
0xE1	'4' = 0x34	CAP100 is requested to send the mean set of the respiration rate
0xE1	'a' = 0x61	CAP100 is requested to send the mode set regarding the ability to fly (option)
0xE1	'd' = 0x64	CAP100 is requested to send the N <sub>2</sub> O compensation setting
0xE1	'h' = 0x68	CAP100 is requested to send the intake flow set

After the commands above being requested CAP100 sends the following replies:

Identificat ion	Status reply Code/Byte	Meaning
0xE1	'1' = 0x31	No mean for etCO <sub>2</sub>
0xE1	'2' = 0x32	Mean for 2 etCO <sub>2</sub> values
0xE1	'3' = 0x33	Mean for 4 etCO <sub>2</sub> values
0xE1	'5' = 0x35	No mean for the respiration rate
0xE1	'6' = 0x36	Mean for 2 respiration rate values
0xE1	'7' = 0x37	Mean for 4 respiration rate values
0xE1	'b' = 0x62	Flight use on (increased barometer measurements 1/min, option)
0xE1	'c' = 0x63	Flight use off (option)
0xE1	'e' = 0x65	Nitrous oxide gas compensation switched off
0xE1	'f' = 0x66	Nitrous oxide gas compensation of 30 %vol. N <sub>2</sub> O
0xE1	'g' = 0x67	Nitrous oxide gas compensation of 70 %vol. N <sub>2</sub> O
0xE1	'i' = 0x69	Pump switched off
0xE1	'j' = 0x6A	Pump has a flow of 50 ml/min
0xE1	'k' = 0x6B	Pump has a flow of 100 ml/min
0xE1	'l' = 0x6C	Pump has a flow of 150 ml/min

### 8.3.3 Settings

Various parameters can be set. Some settings are saved in the EEPROM and remain intact after being restarted (see settings marked with (\*)).

You have to send the following commands to CAP100, so that the settings desired become active:

Identificat ion	Settings code/byte	Meaning
0xE1	'1' = 0x31	No mean for etCO <sub>2</sub> value (*)
0xE1	'2' = 0x32	Mean for 2 etCO <sub>2</sub> values (*)
0xE1	'3' = 0x33	Mean for 4 etCO <sub>2</sub> values (*)
0xE1	'5' = 0x35	No mean for the respiration rate (*)
0xE1	'6' = 0x36	Mean for 2 respiration rate values (*)
0xE1	'7' = 0x37	Mean for 4 respiration rate values (*)
0xE1	'b' = 0x62	Switch on flight mode (*)

0xE1	'c' = 0x63	Switch off flight mode (*)
0xE1	'e' = 0x65	Nitrous oxide gas compensation switched off (when the system is started the laughing gas compensation is always switched off)
0xE1	'f' = 0x66	Nitrous oxide gas compensation of 30 %vol. N <sub>2</sub> O
0xE1	'g' = 0x67	Nitrous oxide gas compensation of 70 %vol. N <sub>2</sub> O
0xE1	'i' = 0x69	Pump switched off
0xE1	'j' = 0x6A	Pump has a flow of 50 ml/min (*)
0xE1	'k' = 0x6B	Pump has a flow of 100 ml/min (*)
0xE1	'l' = 0x6C	Pump has a flow of 150 ml/min (*)
0xE1	'm' = 0x6D	Optional for analog output: switch-over of the output voltage from 0-1V to 0-100 mV and vice versa (*)
0xE1	'w' = 0x77	Optional for analog output: on the analog output signal a scaling signal is triggered.
0xE1	'q' = 0x71	Triggers a calibration with dark value measurement
0xE1	'x' = 0x78	The CO <sub>2</sub> values are transferred in mmHg (*)
0xE1	'y' = 0x79	The measured CO <sub>2</sub> values are transferred in % vol. ( <b>Attention:</b> values are multiplied by factor 10) (*)
0xFB	'R' = 0x52	Resetting the system (hardware reset)
0xFB	'r' = 0x72	Resetting the system (software reset)

## 9 CAP100 demo kit

The CAP100 demo kit includes:

- 1 CAP100 module
- 1 software program CO2Demo.exe to test the module (program runs under DOS)
- Motherboard with serial adapter for RS232 connection and possibilities for a hardware add-on for customer specific requirements
- 1 set patient tubes
- 1 set of Teflon filters
- 1 set of adapter tubes
- CO<sub>2</sub> absorber cartridge

The demo kit is a complete capnograph system to display the measured values on a PC. All measured parameters such as capnogram; respiration rate and etCO<sub>2</sub> value of the module are serially transferred to your PC. Additionally, you can save the data transferred onto your hard disk.

### 9.1 Connection of sample tubes

Also see chapter Initial operation.

Connect the patient tube with the tube adapter through the Teflon filter to the Nafion tube. Never use the module without the Teflon filter and Nafion tube.

- The module CAP100 has an input for reference air. CAP100 carries out automatic zero point calibrations during operation, by switching over a valve to the reference air. On no account may CO<sub>2</sub> penetrate the input for the reference air. Therefore insure the ambient air is free of CO<sub>2</sub>.

### 9.2 Connection to the PC

#### 9.2.1 Supply and RS232 connection only with CAP100 module without motherboard

- Use an adapter from TTL to RS232, to connect the module to the PC (TTL port CAP100 JP 4).
- Connect the supply voltage of 7-15 V (min 250 mA) to JP3.

(Please follow the illustration in chapter 6)

### 9.2.2 Supply and RS232 connection with motherboard

The motherboard is connected through a 9-pole SUB D connector.

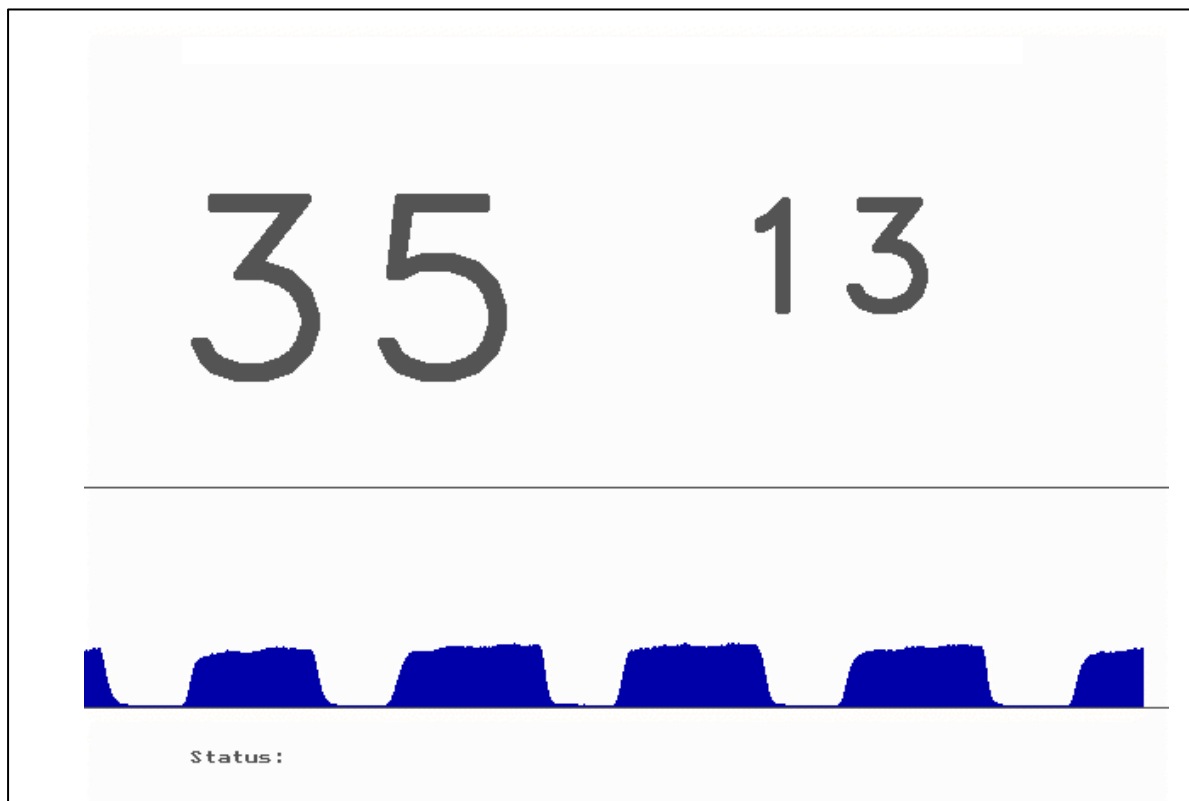
9-pole sub socket on the motherboard:

Pin no.	Function
1	N.C.
2	RXD of CAP-100 (RS232)
3	TXD of CAP-100(RS232)
4	Channel B (analog output option)
5	AGND as well as RS232 Not for supply!!!
6	N.C.
7	GND supply
8	V+ (7-15 V)
9	Channel A (analog output option)

**N.B:** Only supply CAP100 through this sub D connector and not to CAP-100 through JP 3. Only connect the ground of the supply voltage to PIN 7 and not to PIN 5! Connect the ground of the serial port to PIN 5.

### 9.3 Starting the demo program

After you have started the demo program with the necessary parameters, the data is transferred through the port selected (COMx). The capnogram curve, the etCO<sub>2</sub> value and the respiration rate are depicted.



Top left:	etCO <sub>2</sub> /mmHg
Top right:	Respiration rate /min
Capnogram:	0-75 mmHg / 0-9.9%vol.
Status:	Status messages, error messages

#### Program call-up and program parameters:

CO2DEMO.EXE COMx [switch]

COMx: COM1-COM4

#### Program switches:

- -h, -?: Program help
- -g: German program execution (default = English)
- -k: No waiting for pressing the key after runtime errors or program start
- -ITTT: Data storage in ASCII format in a "KAPNOxxx.pol" file.
- -r: Binary data recording in a "KAPNOxxx.POB file. All data sent by CAP100 is recorded.

**Data storage:**

"xxx" is a continuous file number, which starts with the ending 000. The program automatically increases the file number (e.g. 001). As a result the old file is not overwritten. TTT corresponds with the recording rate in milliseconds. At recording rates of 40 ms, the capnogram curve is saved. At TTT>40 ms only the respiration rate (bpm) and the etCO<sub>2</sub> value are saved.

E.g.: TTT= 40 ms

Time	etCO2	bpm	Capnogram
13:30:45	38	23	31
13:30:46	38	23	32

E.g.: TTT= 2000 ms

Time	etCO2	bpm
13:30:44	38	23
13:30:46	38	23

**9.4 Help**

You are able to call up help whilst the program is running. To do this press F1 on your PC. You can set or query the following parameters:

<b>Key pressed on your PC</b>	<b>Meaning</b>
" F1, ?	: Calling up Help "
" ESC, F10, ALT-X	: End of program"
" ALT-S	: Scroll mode"
" ALT-F	: Freezing the capnogram "
" ALT-R, STRG-R	: Software reset, hardware reset "
" ALT-T	: Toggle between bar graph <=> capnogram "
" ALT-V	: Query software version"
" STRG-D	: Query current date and time"
" F2	: !! Initiate CO2 calibration !! "
" o	: Confirm occlusion "
" 0 4	: Query CO2 (0) - AF (4) mean"
" 1-3 5-7	: Set CO2 (1,2,3,) - AF (5,6,7) mean"
" d	: Query N <sub>2</sub> O gas setting"
" e - f - g	: N <sub>2</sub> O gas settings (0%, 30%, 70% N <sub>2</sub> O)"
" h	: "Query flow"

" i - j - k - l	:	"Flow settings"
" p	:	Auto. pump test "
" q	:	Initiate zero point calibration "
" x	:	Display in mmHg "
" y	:	Display in % vol. "
Analog output option:		
" m	:	Toggle reference voltage between 100mV / 1V "
" w	:	Initiate scaling signal "
Flight use option		
" a	:	Query flight mode "
" b	:	Flight mode on "
" c	:	Flight mode off "

## 10 Maintenance

### 10.1 Annual maintenance

CAP100 should be serviced regularly once a year. In the course of the service the module should be completely reconditioned (calibration review, exchange of parts subject to wear).

<b>Service life assessment</b>	
Pump	min.5000 h
Light source	40000 h
Sensor	3 years
Valve	200 mill cycles
Pressure sensor (long-term stability over 1 year )	±0.1% FSO

### 10.2 Calibration check

We recommend you to subject CAP100 to a calibration check approx. every 3 months. You should also carry out a calibration check if you believe that your measured results could be wrong. If the calibration check should provide an incorrect result, a calibration must be carried out as described in the following chapter.

To carry out a calibration check, run CAP100 approx. 15 minutes in normal operating mode and measure CAP100 with reference gasses which have a defined CO<sub>2</sub> concentration. Please use only gasses which contain CO<sub>2</sub> with residual oxygen.

## 11 Technical specifications

<b>General specifications:</b>		
Dimensions (wxdxh):		90 x 78 x 25 mm
Measurement procedure: IR photometric procedure		
Tested according to:	radiated electromagnetic fields (IEC 1000-4-3) Emission of radiated interference parameters (EN 55011:1991) EN 864	
<b>Ambient conditions:</b>		
Operating temperature range		5 - 40 °C
Storage temperature range		-20 - +70 °C
Humidity		0 - 95 % (non cond.)
<b>Performance characteristics:</b>		
Average current or power drain		1.3 VA
Supply voltage		7-15V
Measurement range and accuracy CO <sub>2</sub> module:		
etCO <sub>2</sub> range in mmHg		3-75 mmHg
etCO <sub>2</sub> range in %vol.		0.4-9.9 %vol.
Capnogram curve output range		0-75mmHg. 0.0-9.9 %vol.
etCO <sub>2</sub> accuracy	3 – 40mm Hg (up to 120 bpm) 0.4 - 5.0%vol. 41 – 75mmHg (up to 120 bpm) 5.4 - 9.9 %vol.	± 2 mmHg ±0.2%vol. ± 6% of measured value
Respiration rate range, incl. Newborns		2-120 bpm
Respiration rate accuracy 2-120 bpm		± 1 bpm
Respiration rate mean		1,2,4 adjustable
etCO <sub>2</sub> value display mean		1,2,4 adjustable
Absolute pressure range		600-1050 mbar
Absolute pressure accuracy		± 5 mbar
Flow adjustable		50 ml/min 100 ml/min 150 ml/min
Integrated water vapor correction		

Definition respiratory cycle: capnogram must drop to 75 % of end tidal value in the inspiration phase, and subsequently rise again	
Readiness to operate after start-up, CO <sub>2</sub> accuracy = ± 5 mmHg	After 15 sec.
Readiness to operate after start-up for meeting all specifications	After 5 min
Communication	
RS232 bi-directional	TTL level
Protocol	9600 bd, data bit, stop bit, no parity
Optional: 2 analog outputs	8 bit resolution
Output via RS232	
Capnogram curve	0-75 mmHg 0.0 - 9.9%vol.
etCO <sub>2</sub>	3-75 mmHg 0.4 - 9.9 %vol.
Respiration rate	2-120/min
<b>Analog output:</b>	
Channel A etCO <sub>2</sub> (3-75 mmHg)	0-1V/ 0-100mV
Channel B capnogram (3-75 mmHg)	0-1V/0-100mV
<b>Setting possibilities CO<sub>2</sub> module:</b>	
All settings through RS232 with MCC protocol	
etCO <sub>2</sub> mean, factory setting = 2	1 - 2 - 4
Respiration rate mean, factory setting = 2	1 - 2 - 4
Flow, factory setting = 100 ml/min Fine adjustment of the flow through PC demo program	50 ml/min 100 ml/min 150 ml/min
Laughing gas compensation, : factory setting = 0 %	0, 30%, 70% N <sub>2</sub> O
Ability to fly, factory setting = off	On/off (optional)
Triggering zero point calibration	
Occlusion confirmation	
Triggering software and hardware reset	
Factory calibration by the user	2.5, 5, 10 % CO <sub>2</sub>
<b>Status queries:</b>	
Mean settings	etCO <sub>2</sub> + respiration rate
Firmware version	
Laughing gas settings	
Intake flow	

Flight use	Optional
<b>Status messages:</b>	
Zero point calibration	Identification
Internal error messages (after error_no.h)	Identification + error
Occlusion message (intake line blocked)	Identification
System error	Error no.
Self test	

## 12 CE marking

CAP100 is not a finished medical product and can therefore not be subjected to any official certification. The OEM customer is responsible for any certifications incorporating the module in a finished product.

## 13 Warranty

We offer an one years warranty from the date of delivery for all defects arising from manufacturing or material faults.

Particularly not covered by the warranty conditions are any defects or faults of the instruments function arising from disobedience of this operating instruction, improper maintenance, misuse or strange interference. In this cases the product liability is changing to the customer.

Important:

The purchase invoice must be presented when making a claim under the warranty.

Please send devices to be repaired together with all accessories to:

EnviteC-Wismar GmbH

Phillip-Müller-Straße 12

D-23966 Wismar

Germany

Phone: +49-(0)-3841 / 360-0

Fax:: +49-(0)-3841 / 360-222